

What is claimed is:

1. A substrate treatment method for treating a substrate by supplying a treatment liquid to the substrate while rotating the substrate, the method comprising the  
5 steps of:

performing a first substrate rotation process for rotating the substrate while clamping the substrate by a first clamping member set including at least two clamping members;

10 performing a second substrate rotation process after the first substrate rotation step for rotating the substrate while clamping the substrate by the first clamping member set and a second clamping member set provided separately from the first clamping member set and including  
15 at least two clamping members; and

performing a third substrate rotation process after the second substrate rotation step by unclamping the substrate from the first clamping member set for rotating the substrate while clamping the substrate by the second  
20 clamping member set.

2. A substrate treatment method as set forth in claim 1, wherein the clamping of the substrate by the first clamping member set is achieved by at least three clamp pins included in the first clamping member set.

25 3. A substrate treatment method as set forth in claim

1, wherein the clamping of the substrate by the second clamping member set is achieved by at least three clamp pins included in the second clamping member set.

4. A substrate treatment method as set forth in claim  
5 1,

wherein the clamping of the substrate by the first clamping member set is achieved by at least three clamp pins included in the first clamping member set,

wherein the clamping of the substrate by the second  
10 clamping member set is achieved by at least three clamp pins included in the second clamping member set.

5. A substrate treatment method as set forth in claim 1, further comprising the step of supplying the treatment liquid to a surface of the substrate being rotated at least  
15 in the first substrate rotation step and the third substrate rotation step.

6. A substrate treatment method as set forth in claim 5, wherein the treatment liquid supply step comprises the step of supplying an etching liquid for etching away an  
20 unnecessary substance from a peripheral edge portion of the substrate.

7. A substrate treatment method as set forth in claim 1, further comprising the step of supplying the treatment liquid to the substrate prior to the first substrate  
25 rotation step,

wherein the treatment liquid is not supplied to the substrate during any of the first substrate rotation step, the second substrate rotation step and the third substrate rotation step, but a drying process is performed by spinning  
5 off the treatment liquid by the rotation of the substrate.

8. A substrate treatment method as set forth in claim 1,

wherein the clamping members of at least one of the first clamping member set and the second clamping member  
10 set each have at least two abutment portions which are selectively brought into abutment against the substrate,

the method further comprising the step of switchably bringing the at least two abutment portions into abutment against the substrate.

15 9. A substrate treatment method as set forth in claim 1,

wherein the first clamping member set includes three clamping members each having a first abutment portion and a second abutment portion which are selectively brought  
20 into abutment against the substrate, and the second clamping member set includes three clamping members each having a third abutment portion which is brought into abutment against the substrate,

wherein the first substrate rotation step comprises  
25 the step of bringing the first abutment portions of the

three clamping members of the first clamping member set into abutment against the substrate for clamping the substrate,

wherein the second substrate rotation step  
5 comprises the step of bringing the third abutment portions of the three clamping members of the second clamping member set into abutment against the substrate with the first abutment portions of the three clamping members of the first clamping member set kept in abutment against the substrate,

10 wherein the third substrate rotation step comprises the step of retracting the first abutment portions of the three clamping members of the first clamping member set from the substrate,

the method further comprising the steps of:

15 performing a fourth substrate rotation process after the third substrate rotation step by bringing the second abutment portions of the three clamping members of the first clamping member set into abutment against the substrate with the third abutment portions of the three  
20 clamping members of the second clamping member set kept in abutment against the substrate for rotating the substrate while clamping the substrate by the first and second clamping member sets; and

performing a fifth substrate rotation process after  
25 the fourth substrate rotation step by retracting the third

abutment portions of the three clamping members of the second clamping member set from the substrate to unclamp the substrate from the second clamping member set for rotating the substrate while clamping the substrate by the first substrate clamping member set.

10. A substrate treatment method as set forth in claim 9,

wherein the three clamping members of the second clamping member set each have the third abutment portion and a fourth abutment portion which are selectively brought into abutment against the substrate,

the method further comprising the steps of:

performing a sixth substrate rotation process after the fifth substrate rotation step by bringing the fourth abutment portions of the three clamping members of the second clamping member set into abutment against the substrate with the second abutment portions of the three clamping members of the first clamping member set kept in abutment against the substrate for rotating the substrate while clamping the substrate by the first and second clamping member sets; and

performing a seventh substrate rotation process after the sixth substrate rotation step by retracting the second abutment portions of the three clamping members of the first clamping member set from the substrate to unclamp

the substrate from the first clamping member set for rotating the substrate while clamping the substrate by the second clamping member set.

11. A substrate treatment method as set forth in claim 5 9, further comprising the step of supplying the treatment liquid to a surface of the substrate being rotated at least in the first substrate rotation step, the third substrate rotation step and the fifth substrate rotation step.

12. A substrate treatment method as set forth in claim 10 10, further comprising the step of supplying the treatment liquid to a surface of the substrate being rotated at least in the first substrate rotation step, the third substrate rotation step, the fifth substrate rotation step and the seventh substrate rotation step.

13. A substrate treatment method as set forth in claim 15 11, wherein the treatment liquid supply step comprises the step of supplying an etching liquid for etching away an unnecessary substance from a peripheral edge portion of the substrate.

14. A substrate treatment method as set forth in claim 20 12, wherein the treatment liquid supply step comprises the step of supplying an etching liquid for etching away an unnecessary substance from a peripheral edge portion of the substrate.

15. A substrate treatment method as set forth in claim 25

9, further comprising the step of supplying the treatment liquid to the substrate prior to the first substrate rotation step,

wherein the treatment liquid is not supplied to the  
5 substrate during any of the first to fifth substrate rotation steps, but a drying process is performed by spinning off the treatment liquid by the rotation of the substrate.

16. A substrate treatment method as set forth in claim  
10 10, further comprising the step of supplying the treatment liquid to the substrate prior to the first substrate rotation step,

wherein the treatment liquid is not supplied to the substrate during any of the first to seventh substrate  
15 rotation steps, but a drying process is performed by spinning off the treatment liquid by the rotation of the substrate.

17. A substrate treatment apparatus comprising:

a substrate holding mechanism comprising a first  
20 clamping member set including at least two clamping members, and a second clamping member set provided separately from the first clamping member set and including at least two clamping members;

a rotative drive mechanism for rotating the  
25 substrate holding mechanism;

a first clamping member drive mechanism for driving the first clamping member set;

a second clamping member drive mechanism for driving the second clamping member set; and

5 a controller for independently controlling the first clamping member drive mechanism and the second clamping member drive mechanism.

18. A substrate treatment apparatus as set forth in claim 17, wherein the controller controls the rotative drive  
10 mechanism, the first clamping member drive mechanism and the second clamping member drive mechanism to perform a first substrate rotation process for rotating the substrate holding mechanism while clamping the substrate by the first clamping member set, to perform a second substrate rotation  
15 process after the first substrate rotation process for rotating the substrate holding mechanism while clamping the substrate by the first clamping member set and the second clamping member set, and to perform a third substrate rotation process after the second substrate rotation  
20 process by unclamping the substrate from the first clamping member set for rotating the substrate holding mechanism while clamping the substrate by the second clamping member set.

19. A substrate treatment apparatus as set forth in claim  
25 17,



wherein the clamping members of at least one of the first clamping member set and the second clamping member set each have at least two abutment portions which are selectively brought into abutment against the substrate,

5 wherein the controller performs an abutment portion switching process for switchably bringing the at least two abutment portions into abutment against the substrate.

20. A substrate treatment apparatus as set forth in claim 17, wherein the controller is capable of controlling the  
10 first clamping member drive mechanism and the second clamping member drive mechanism so as to clamp the substrate by both the first clamping member set and the second clamping member set.

21. A substrate treatment apparatus as set forth in claim  
15 17,

wherein the substrate holding mechanism comprises a rotary member including a rotary shaft rotatively driven by the rotative drive mechanism, a first substrate clamping mechanism including the first clamping member set, and a  
20 second substrate clamping mechanism including the second clamping member set,

wherein the first clamping member drive mechanism comprises a first non-rotative movable member which is movable parallel to the rotary shaft, a first driving  
25 mechanism for moving the first non-rotative movable member

parallel to the rotary shaft, a first rotative movable member which is movable parallel to the rotary shaft in association with movement of the first non-rotative movable member by a driving force received from the first

5 non-rotative movable member and is rotatable together with the rotary member, and a first movement converting mechanism for converting movement of the first rotative movable member into movement of the first substrate clamping member set,

wherein the second clamping member drive mechanism

10 comprises a second non-rotative movable member which is movable parallel to the rotary shaft, a second driving mechanism for moving the second non-rotative movable member parallel to the rotary shaft, a second rotative movable member which is movable parallel to the rotary shaft in

15 association with movement of the second non-rotative movable member by a driving force received from the second non-rotative movable member and is rotatable together with the rotary member, and a second movement converting mechanism for converting movement of the second rotative

20 movable member into movement of the second substrate clamping member set.

22. A substrate treatment apparatus as set forth in claim 21, wherein the controller controls the first and second driving mechanisms to switch, when the rotary member is

25 rotated by the rotative drive mechanism, a substrate

clamping state between a first clamping state where the substrate is clamped by the clamping members of the first substrate clamping mechanism and unclamped by the clamping members of the second substrate clamping mechanism and a  
5 second clamping state where the substrate is clamped by the clamping members of the second substrate clamping mechanism and unclamped by the clamping members of the first substrate clamping mechanism.

23. A substrate treatment apparatus as set forth in claim  
10 21, wherein at least one of the first non-rotative movable member and the first rotative movable member is configured annularly about the rotary shaft, and at least one of the second non-rotative movable member and the second rotative movable member is configured annularly about the rotary  
15 shaft.

24. A substrate treatment apparatus as set forth in claim  
21,

wherein the first driving mechanism and the second driving mechanism comprise a first driving force source  
20 and a second driving force source, respectively, which are independently controllable,

wherein the controller controls the first driving force source and the second driving force source independently.

25 25. A substrate treatment apparatus as set forth in claim

21, further comprising a first driving force transmission mechanism for transmitting the driving force from the first non-rotative movable member to the first rotative movable member while permitting relative rotation of the first  
5 rotative movable member with respect to the first non-rotative movable member about the rotary shaft.

26. A substrate treatment apparatus as set forth in claim 25, wherein the first driving force transmission mechanism comprises a first annular bearing which couples the first  
10 non-rotative movable member and the first rotative movable member so as to permit the relative rotation of the first rotative movable member with respect to the first non-rotative movable member about the rotary shaft.

27. A substrate treatment apparatus as set forth in claim 15 25, wherein the first driving force transmission mechanism comprises a plurality of first rolling members provided on at least one of the first non-rotative movable member and the first rotative movable member so as to be rolled on a surface of the other movable member.

20 28. A substrate treatment apparatus as set forth in claim 25, wherein the first driving force transmission mechanism comprises a first stationary magnet and a first rotary magnet respectively provided on the first non-rotative movable member and the first rotative movable member with  
25 opposed poles thereof having the same polarity.

29. A substrate treatment apparatus as set forth in claim 25, wherein the first driving force transmission mechanism comprises a first gas supply mechanism for supplying a gas between the first non-rotative movable member and the first  
5 rotative movable member so as to keep the first non-rotative movable member and the first rotative movable member in spaced relation.

30. A substrate treatment apparatus as set forth in claim 25, further comprising a second driving force transmission  
10 mechanism for transmitting the driving force from the second non-rotative movable member to the second rotative movable member while permitting relative rotation of the second rotative movable member with respect to the second non-rotative movable member about the rotary shaft.

15 31. A substrate treatment apparatus as set forth in claim 30, wherein the second driving force transmission mechanism comprises a second annular bearing which couples the second non-rotative movable member and the second rotative movable member so as to permit the relative rotation of the second  
20 rotative movable member with respect to the second non-rotative movable member about the rotary shaft.

32. A substrate treatment apparatus as set forth in claim 30, wherein the second driving force transmission mechanism comprises a plurality of second rolling members provided  
25 on at least one of the second non-rotative movable member

and the second rotative movable member so as to be rolled on a surface of the other movable member.

33. A substrate treatment apparatus as set forth in claim 30, wherein the second driving force transmission mechanism  
5 comprises a second stationary magnet and a second rotary magnet respectively provided on the second non-rotative movable member and the second rotative movable member with opposed poles thereof having the same polarity.

34. A substrate treatment apparatus as set forth in claim  
10 30, wherein the second driving force transmission mechanism comprises a second gas supply mechanism for supplying a gas between the second non-rotative movable member and the second rotative movable member so as to keep the second non-rotative movable member and the second rotative movable  
15 member in spaced relation.

35. A substrate treatment apparatus as set forth in claim 17, further comprising a treatment fluid supply mechanism for supplying a treatment fluid to a surface of the substrate held and rotated by the substrate holding mechanism.

20 36. A substrate treatment apparatus as set forth in claim 35, wherein the treatment fluid supply mechanism comprises an etching liquid supply mechanism for supplying an etching liquid for removing an unnecessary substance from a peripheral edge portion of the substrate held and rotated  
25 by the substrate holding mechanism.

37. A substrate treatment apparatus comprising:

a rotary member having a rotary shaft and a plurality of clamping members which are capable of clamping and unclamping a substrate, the rotary member being rotatable  
5 about the rotary shaft;

a rotative drive mechanism for applying a torque to the rotary shaft to rotatively drive the rotary member;

a non-rotative movable member which is movable parallel to the rotary shaft;

10 a driving mechanism for moving the non-rotative movable member parallel to the rotary shaft;

a rotative movable member which is movable parallel to the rotary shaft in association with movement of the non-rotative movable member by a driving force received  
15 from the non-rotative movable member and is rotatable together with the rotary member;

a movement converting mechanism for converting movement of the rotative movable member into movements of the clamping members of the rotary member; and

20 a controller for operating the driving mechanism so that the substrate is completely or slightly released from the clamping members and then clamped again by the clamping members while the rotary member is rotated by the rotative drive mechanism.

25 38. A substrate treatment apparatus as set forth in claim

37, wherein at least one of the non-rotative movable member and the rotative movable member is configured annularly about the rotary shaft.

39. A substrate treatment apparatus as set forth in claim 5 37, wherein the controller controls the rotative drive mechanism to accelerate or decelerate the rotation of the rotary member when the substrate is completely or slightly released from the clamping members.

40. A substrate treatment apparatus as set forth in claim 10 37,

wherein the clamping members each have a first abutment portion and a second abutment portion which are selectively brought into abutment against the substrate,

wherein the controller operates the driving 15 mechanism so that the first abutment portion and the second abutment portion are switchably brought into abutment against the substrate during the rotation of the rotary member.

41. A substrate treatment apparatus as set forth in claim 20 37, further comprising a driving force transmission mechanism for transmitting a driving force from the non-rotative movable member to the rotative movable member while permitting relative rotation of the rotative movable member with respect to the non-rotative movable member about 25 the rotary shaft.



42. A substrate treatment apparatus as set forth in claim 41, wherein the driving force transmission mechanism comprises an annular bearing which couples the non-rotative movable member and the rotative movable member so as to  
5 permit the relative rotation of the rotative movable member with respect to the non-rotative movable member about the rotary shaft.

43. A substrate treatment apparatus as set forth in claim 41, wherein the driving force transmission mechanism  
10 comprises a plurality of rolling members provided on at least one of the non-rotative movable member and the rotative movable member so as to be rolled on a surface of the other movable member.

44. A substrate treatment apparatus as set forth in claim  
15 41, wherein the driving force transmission mechanism comprises a stationary magnet and a rotary magnet respectively provided on the non-rotative movable member and the rotative movable member with opposed poles thereof having the same polarity.

20 45. A substrate treatment apparatus as set forth in claim 41, wherein the driving force transmission mechanism comprises a gas supply mechanism for supplying a gas between the non-rotative movable member and the rotative movable member so as to keep the non-rotative movable member and  
25 the rotative movable member in spaced relation.

46. A substrate treatment apparatus as set forth in claim 37, further comprising a treatment fluid supply mechanism for supplying a treatment fluid to a surface of the substrate held and rotated by the substrate holding mechanism.

5 47. A substrate treatment apparatus as set forth in claim 46, wherein the treatment fluid supply mechanism comprises an etching liquid supply mechanism for supplying an etching liquid for removing an unnecessary substance from a peripheral edge portion of the substrate held and rotated  
10 by the substrate holding mechanism.

48. A substrate treatment method comprising the steps of:

providing a rotary member rotatable about a rotary shaft and having a plurality of clamping members which are  
15 capable of clamping and unclamping a substrate;

providing a non-rotative movable member which is movable parallel to the rotary shaft;

providing a rotative movable member which is movable parallel to the rotary shaft in association with movement  
20 of the non-rotative movable member by a driving force received from the non-rotative movable member and is rotatable together with the rotary member;

providing a movement converting mechanism for converting movement of the rotative movable member into  
25 movements of the clamping members of the rotary member;

rotating the rotary member by a rotative drive mechanism;

moving the non-rotative movable member parallel to the rotary shaft to completely or slightly release the  
5 substrate from the clamping members in the rotary member rotation step; and

moving the non-rotative movable member parallel to the rotary shaft to clamp the substrate again by the clamping members after the complete/slight release step.

10 49. A substrate treatment method as set forth in claim 48, further comprising the step of controlling the rotative drive mechanism to accelerate or decelerate the rotation of the rotary member in the complete/slight release step.

50. A substrate treatment method as set forth in claim  
15 48, further comprising the step of supplying a treatment fluid to a surface of the substrate held and rotated by the rotary member.

51. A substrate treatment method as set forth in claim 50, wherein the treatment fluid supply step comprises the  
20 step of supplying an etching liquid for removing an unnecessary substance from a peripheral edge portion of the substrate held and rotated by the rotary member.

52. A substrate treatment method comprising the steps of:

25 providing a rotary member rotatable about a rotary

shaft and comprising a first substrate clamping mechanism and a second substrate clamping mechanism each having a plurality of clamping members which are capable of clamping and unclamping a substrate;

5            providing a first non-rotative movable member which is movable parallel to the rotary shaft;

             providing a second non-rotative movable member which is movable parallel to the rotary shaft;

             providing a first rotative movable member which is  
10 movable parallel to the rotary shaft in association with movement of the first non-rotative movable member by a driving force received from the first non-rotative movable member and is rotatable together with the rotary member;

             providing a second rotative movable member which  
15 is movable parallel to the rotary shaft in association with movement of the second non-rotative movable member by a driving force received from the second non-rotative movable member and is rotatable together with the rotary member;

             providing a first movement converting mechanism for  
20 converting movement of the first rotative movable member into movement of the first substrate clamping mechanism of the rotary member;

             providing a second movement converting mechanism  
for converting movement of the second rotative movable  
25 member into movement of the second substrate clamping

mechanism of the rotary member;

performing a first clamping process by controlling positions of the first and second non-rotative movable members along the rotary shaft for keeping a substrate  
5 clamping state in a first clamping state where the substrate is clamped by the clamping members of the first substrate clamping mechanism and unclamped by the clamping members of the second substrate clamping mechanism;

performing a second clamping process by controlling  
10 the positions of the first and second non-rotative movable members along the rotary shaft for keeping the substrate clamping state in a second clamping state where the substrate is clamped by the clamping members of the second substrate clamping mechanism and unclamped by the clamping  
15 members of the first substrate clamping mechanism; and

switching the substrate clamping state between the first clamping state and the second clamping state when the rotary member is rotated by a rotative drive mechanism.

53. A substrate treatment method as set forth in claim  
20 52, wherein the switching step comprises the step of controlling the positions of the first and second non-rotative movable members so as to switch the substrate clamping state to an intermediate state where the substrate is clamped by the clamping members of the first substrate  
25 clamping mechanism and the second substrate clamping

mechanism when the substrate clamping state is switched between the first clamping state and the second clamping state.

54. A substrate treatment method as set forth in claim 5 52, further comprising the steps of:

causing the rotary member to hold and rotate the substrate; and

supplying a treatment fluid to a surface of the substrate held and rotated by the rotary member in the 10 substrate holding and rotating step.

55. A substrate treatment method as set forth in claim 54, wherein the treatment fluid supply step comprises the step of supplying an etching liquid for removing an unnecessary substance from a peripheral edge portion of 15 the substrate held and rotated by the rotary member.

56. A substrate treatment apparatus comprising:

a substrate rotating member which is rotated about a rotary shaft thereof while holding a substrate;

a plurality of clamping members attached to the 20 substrate rotating member and operative in a substrate clamping state for clamping the substrate and in a substrate unclamping state for unclamping the substrate; and

a link mechanism for associating substrate clamping/unclamping motions of the plural clamping members 25 with rotation of the substrate rotating member;

wherein the link mechanism comprises:

a cam member having a cam surface undulated parallel to the rotary shaft and configured as circularly surrounding the rotary shaft of the substrate rotating member; and

5 a movement converting mechanism attached to the substrate rotating member and including a cam follower which moves generally parallel to the rotary shaft while traveling along the cam surface of the cam member in abutment against the cam surface in association with relative rotation of  
10 the cam member with respect to the substrate rotating member, whereby movement of the cam follower is converted into the substrate clamping/unclamping motions of the plural clamping members.

57. A substrate treatment apparatus as set forth in claim  
15 56, wherein a relationship between the cam surface and the cam follower is defined so that at least one pair of clamping members out of the plural clamping members undergo the substrate clamping/unclamping motions with a timing offset.

20 58. A substrate treatment apparatus as set forth in claim 56, further comprising a mode switching mechanism for switching an operation mode of the link mechanism between an active mode and an inactive mode by changing a distance between the substrate rotating member and the cam surface  
25 of the cam member as measured along the rotary shaft.

59. A substrate treatment apparatus comprising:

a substrate rotating member which is rotated while holding a substrate;

a plurality of clamping members attached to the  
5 substrate rotating member, and operative in a substrate clamping state for clamping the substrate and in a substrate unclamping state for unclamping the substrate;

a link mechanism for associating substrate clamping/unclamping motions of the plural clamping members  
10 with rotation of the substrate rotating member, and causing at least one pair of clamping members out of the plural clamping members to undergo the substrate clamping/unclamping motions with a timing offset; and

a mode switching mechanism for switching an  
15 operation mode of the link mechanism between an active mode and an inactive mode.

60. A substrate treatment apparatus as set forth in claim  
58, wherein the mode switching mechanism switches the operation mode of the link mechanism between the active  
20 mode in which the plural clamping members are brought into the substrate clamping state and into the substrate unclamping state in association with the rotation of the substrate rotating member and the inactive mode in which the plural clamping members are kept in the substrate  
25 clamping state.



61. A substrate treatment apparatus as set forth in claim 58, wherein the mode switching mechanism switches the operation mode of the link mechanism among the active mode in which the plural clamping members are brought into the substrate clamping state and into the substrate unclamping state in association with the rotation of the substrate rotating member, a first inactive mode in which the plural clamping members are kept in the substrate clamping state, and a second inactive mode in which the plural clamping members are kept in the substrate unclamping state.

62. A substrate treatment apparatus as set forth in claim 58, wherein the substrate clamping state in the active mode includes a first substrate clamping state where the substrate is clamped by some of the plural clamping members, a second substrate clamping state where the substrate is clamped by the other clamping members, and an intermediate clamping state where the substrate is clamped by all the clamping members when the substrate clamping state is switched between the first substrate clamping state and the second substrate clamping state.

63. A substrate treatment apparatus as set forth in claim 58, wherein the link mechanism comprises a cycle changing mechanism for changing a substrate clamping/unclamping cycle of the plural clamping members in the active mode.

64. A substrate treatment apparatus as set forth in claim

59, wherein the link mechanism comprises a cycle changing mechanism for changing a substrate clamping/unclamping cycle of the plural clamping members in the active mode.

65. A substrate treatment apparatus as set forth in claim 5 56, further comprising an etching liquid supply mechanism for supplying an etching liquid to a peripheral edge portion of the substrate held by the substrate rotating member.

66. A substrate treatment apparatus as set forth in claim 59, further comprising an etching liquid supply mechanism 10 for supplying an etching liquid to a peripheral edge portion of the substrate held by the substrate rotating member.

67. A substrate treatment method comprising the steps of:

rotating a substrate while holding the substrate 15 by a substrate rotating member;

associating substrate clamping/unclamping motions of a plurality of clamping members attached to the substrate rotating member with rotation of the substrate rotating member, and causing at least one pair of clamping members 20 out of the plural clamping members to undergo the substrate clamping/unclamping motions with a timing offset; and

switching an operation mode between an active mode in which the substrate clamping/unclamping motions of the plural clamping members are associated with the rotation 25 of the substrate rotating member and an inactive mode in

which the substrate clamping/unclamping motions are not associated with the rotation of the substrate rotating member.